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(54) Abstract Title
Universal Serial Bus Switching Device

(57) The switching device 100 connects a selected peripheral 114 to a selected one of three computers 112. The device comprises; a peripheral interface 160, USB computer interfaces 122, a switching means 140,142, a USB data transmission means 148 connectable between the peripheral interface and one of the USB computer interfaces by the switching means, a switching controller 154 in communication with the switching means to control a switching event which connects the peripheral interface to one of the USB computer interfaces, a switching event request input device, which may be a keyboard 190, which when operated causes a switching event request signal 180 to be communicated to the switching controller, causing the peripheral to be connected in communication with the selected one of the computers.

The device allows two users to access three computers simultaneously using a keyboard, monitor, mouse and a group of USB peripherals whilst simultaneously supporting file transfer facilities between the computers.

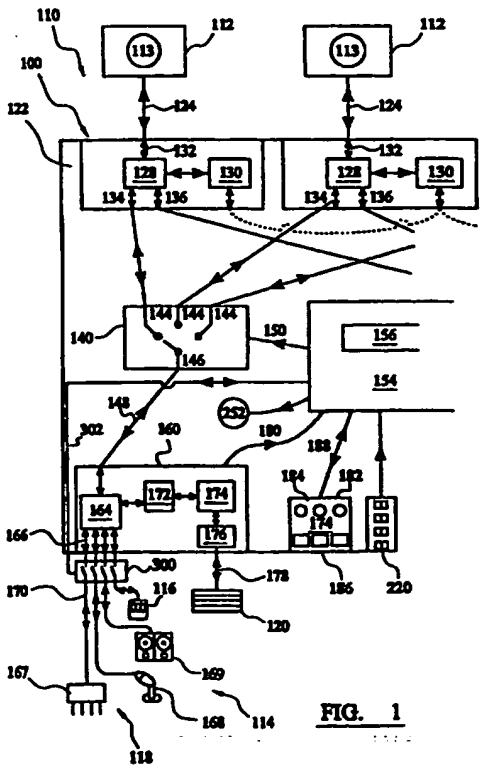

FIG. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

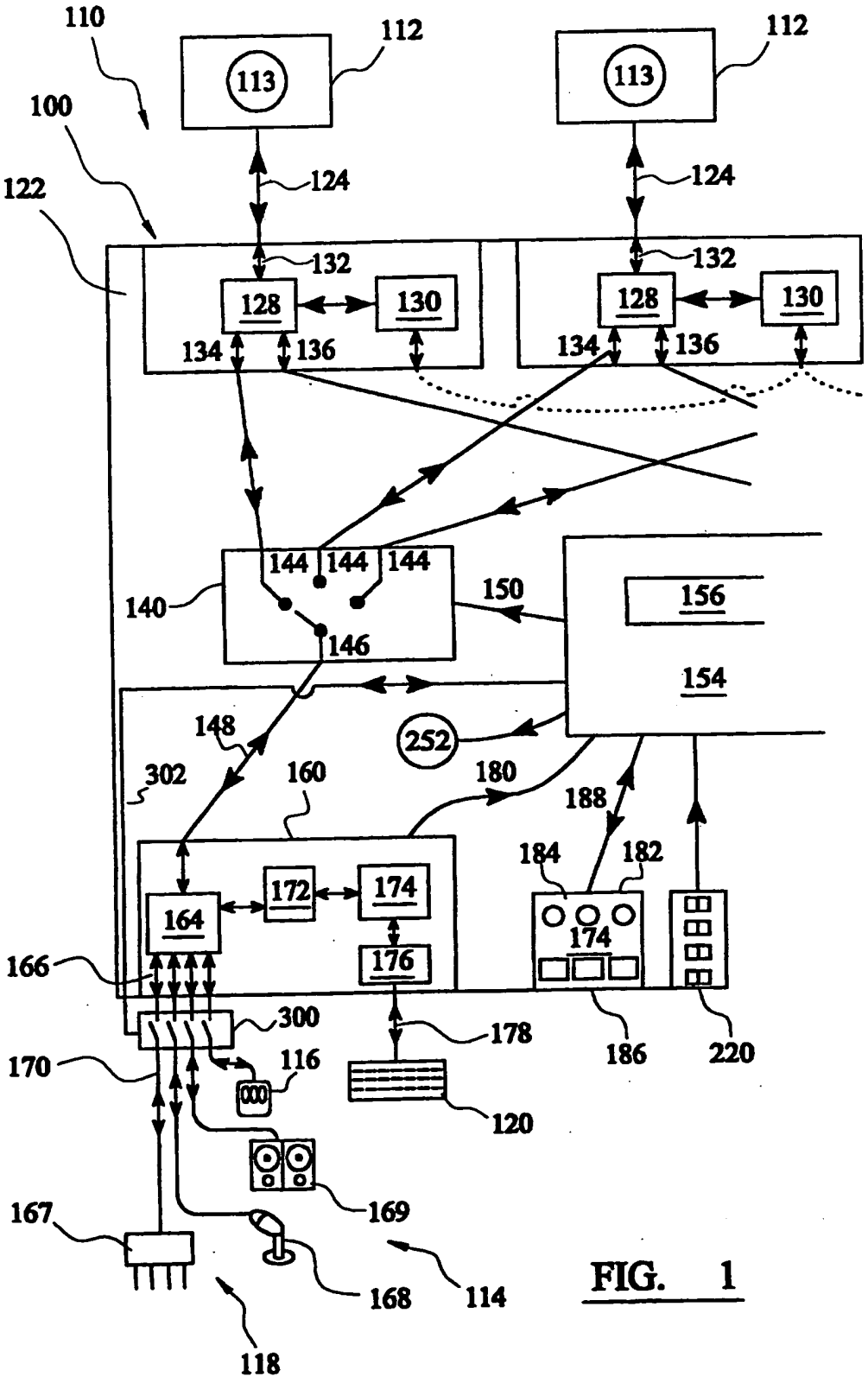
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FIG. 1

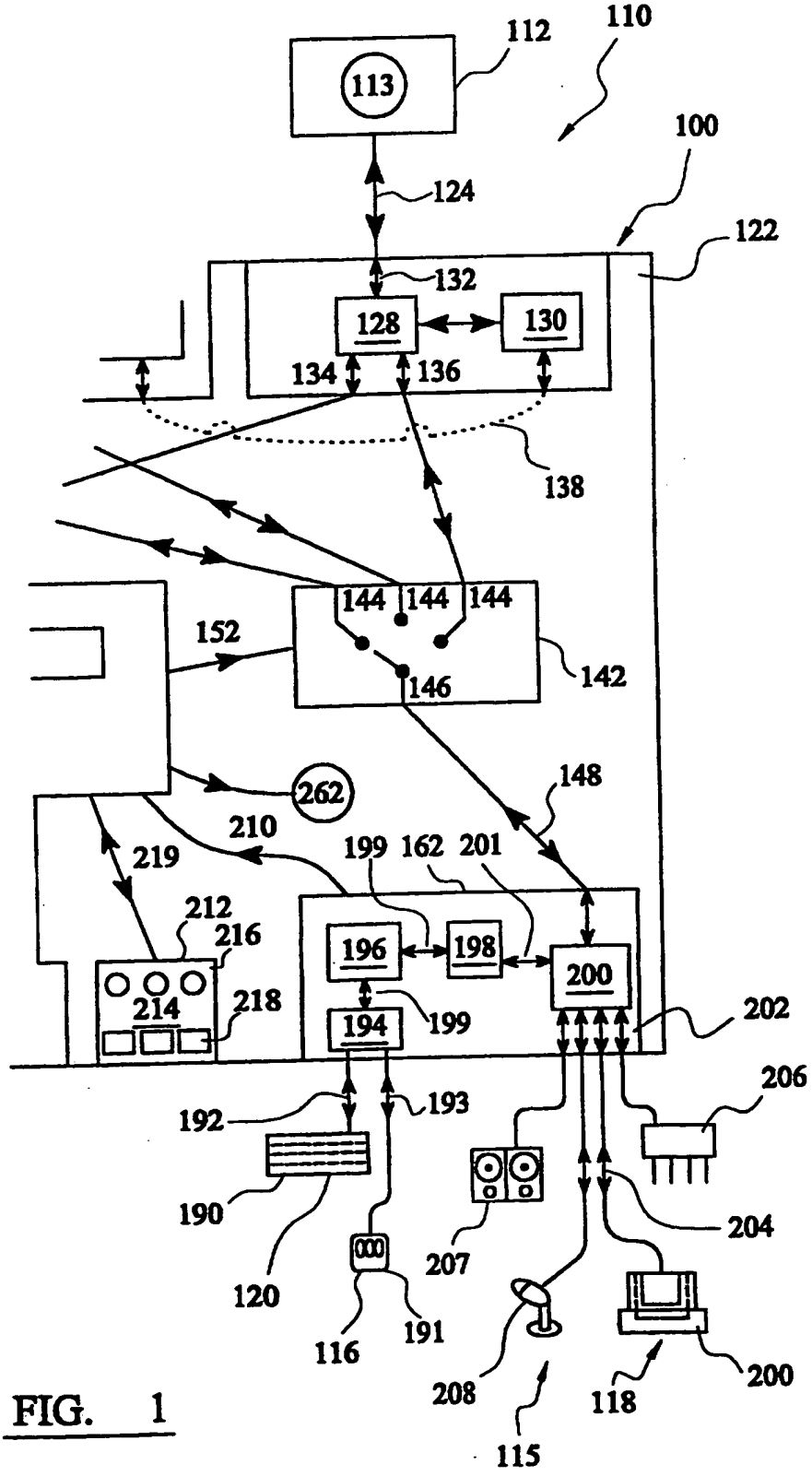
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FIG. 1

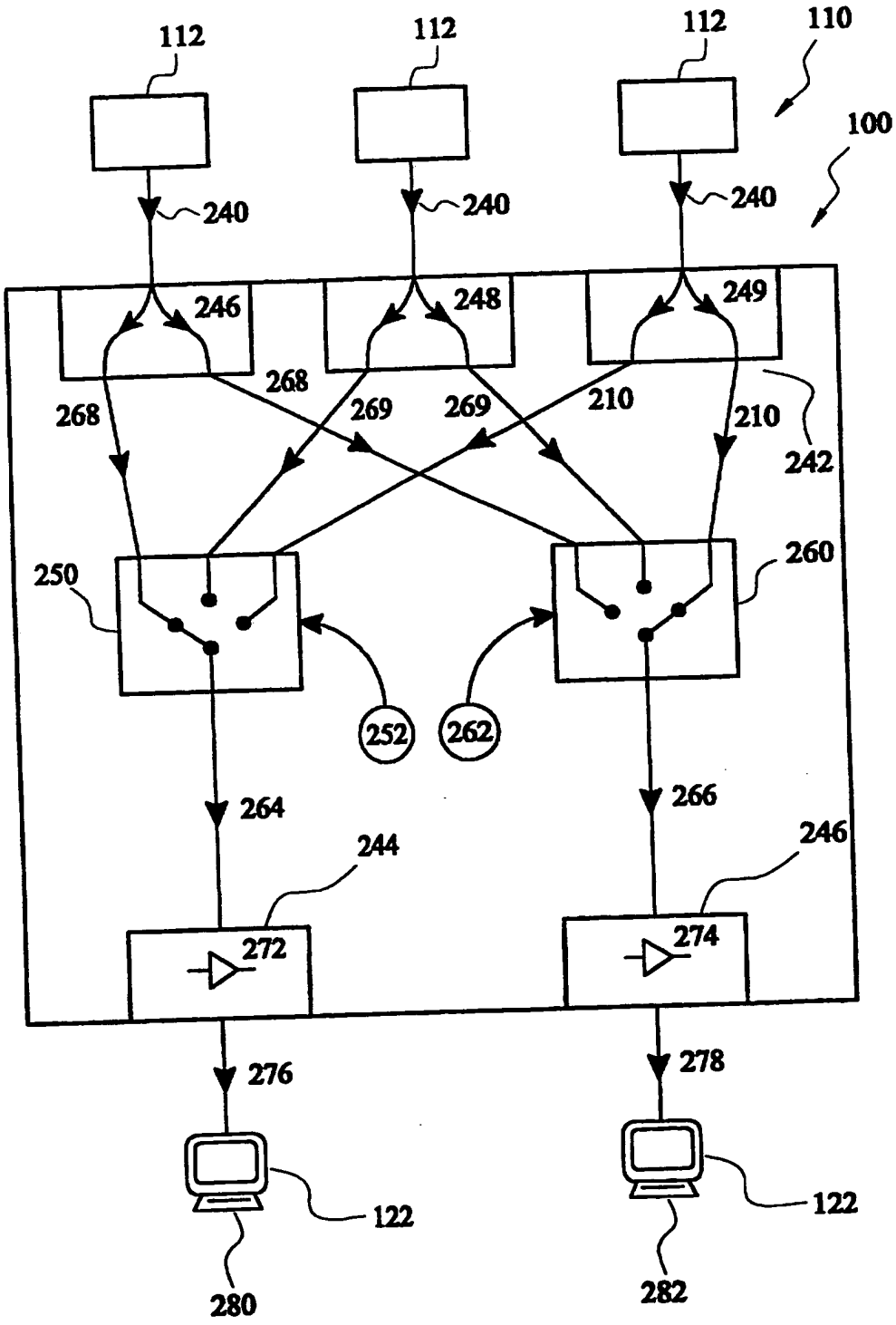
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FIG. 2

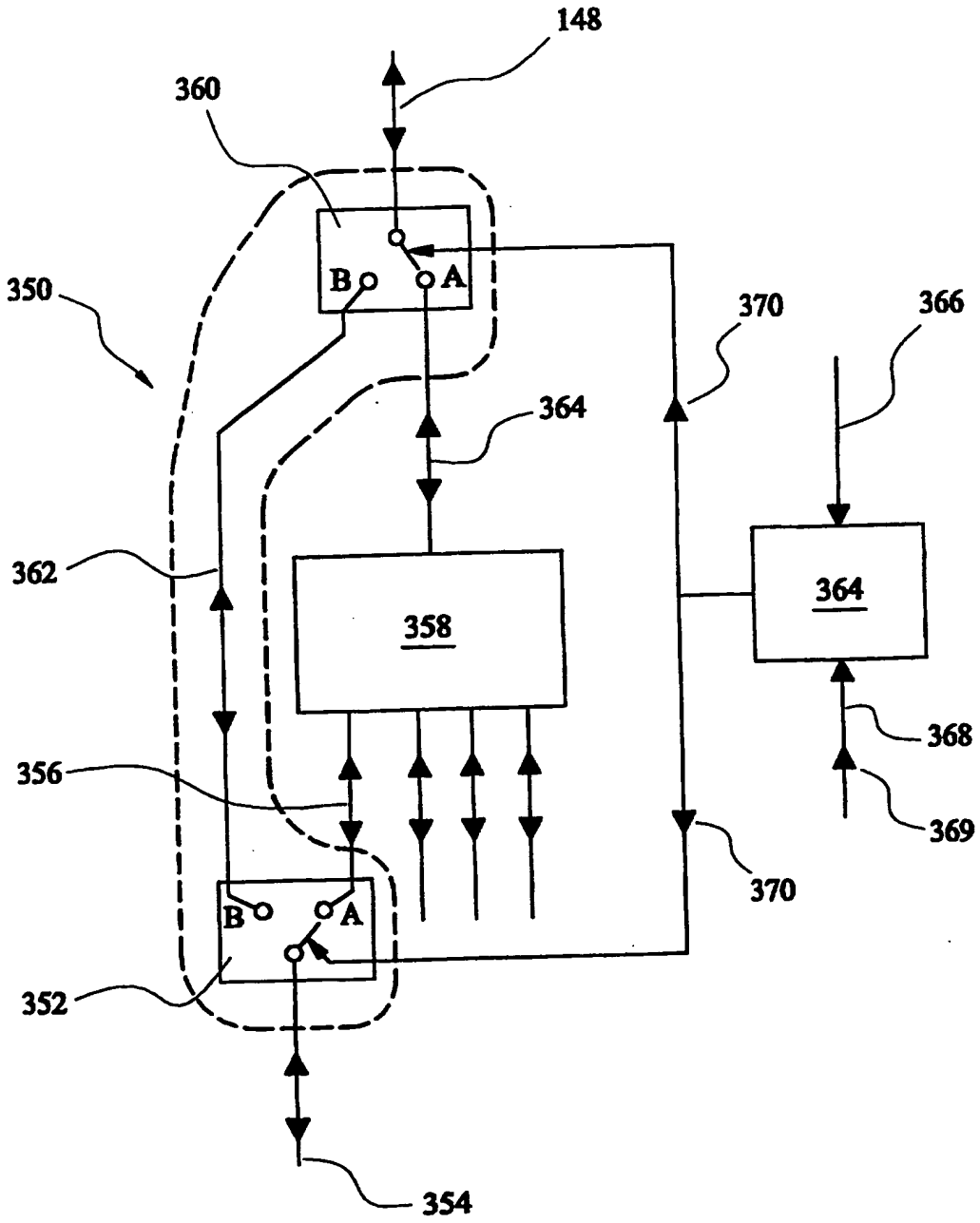

FIG. 3

USB Switching Device and System

The present invention relates to a switching device and a system including such a switching device, and in particular to a Universal Serial Bus switching device for use in connecting peripheral devices to a plurality of computers and such a computer system.

The Universal Serial Bus (USB) is a powerful and convenient way of connecting local peripherals to a host computer. The term 'Universal Serial Bus' relates to the hardware and software that allows a computer to be connected to, and to operate with, a peripheral device. The host computer includes a controller that interfaces the computer with the physical bus, along which signals travel, and to which peripheral devices can be attached. The transmission of data is controlled by a USB protocol which comprises a set of rules, procedures and conventions relating to the format and timing of data transmission between devices. The peripherals are typically printers, scanners, keyboards, mice, speakers, microphones, cameras, joysticks and modems although other peripheral devices are also supported. Multiple peripherals can be connected to a single shared Universal Serial Bus and data transfer between the peripherals and the host computer is achieved by allowing each peripheral to use time on the USB bus in turn. The flow of data across the Universal serial Bus is controlled by the host computer.

It is often desirable for cost, convenience and space saving reasons to share peripherals between groups of computers. This can be achieved by using LAN connections such as Ethernet or by connecting cables from each computer to a sharing device. The wiring of such sharing devices is reasonably straightforward if a single peripheral is to be shared, as a single cable can be connected from the sharing

device to each of the computers. If more than one type of peripheral is to be shared, then the wiring of such systems becomes more complex as multiple cables will typically need to be connected to each computer. The number of cables needed increases with the number of peripherals that are to be supported. For example, a device for sharing a keyboard, mouse and printer between several computers would typically need three cables to be connected between each computer and the sharing device. As the number of peripheral devices increases, such systems become commercially impractical due to the cost and complexity of the multiple sets of multiple cables that are required.

The Universal Serial Bus can be exploited to help to overcome these wiring difficulties by enabling a group of diverse peripherals to be connected using a single common interface. Such wiring simplification is particularly beneficial in sharing applications that would otherwise required multiple sets of multiple cables.

According to an aspect of the present invention there is provided a Universal Serial Bus switching device for connecting a peripheral to a one of a plurality of computers comprising: a peripheral interface; a plurality of USB computer interfaces; a switching means; a USB data transmission means connectable between the peripheral interface and a one of the plurality of USB computer interfaces by the switching means; a switching controller in communication with the switching means to control a switching event which connects the peripheral interface to a one of the plurality of USB computer interfaces; and a switching event request input device which when operated causes a switching event request signal to be communicated to the switching controller, causing the peripheral to be connected in communication with a one of the plurality of computers.

The invention can provide for the sharing of USB peripherals between multiple USB host computers and provides a switching system that takes advantage of the simpler USB wiring whilst also allowing connection to multiple USB host computers.

The Universal Serial Bus is being adopted by a number of different families of computers that previously used different peripheral connections. USB ports can be found on many IBM compatible personal computers as well as a number of Apple Macintosh computers. The adoption of USB ports on other families of computers is likely in the future. The invention therefore has advantages over more traditional sharing solutions because it enables different types of computers to be connected without having to support conversions between different types of interfaces.

The Universal Serial Bus is primarily designed to connect a group of up to 127 peripherals to a single host computer. Sharing peripherals between multiple hosts poses a number of difficulties because different types of peripherals are best shared in different ways. The best sharing strategy for a particular type of peripheral will typically be application dependent. For maximum flexibility the data flowing between the computers and all the peripherals could be extracted from the USB signals and processed in a manner suitable for the application. However, the circuitry to achieve this data extraction is complicated and expensive and so the invention provides a simpler sharing strategy which is more appropriate for certain applications.

One particular application for the invention that can be addressed by a simpler strategy is the sharing of a keyboard, monitor and mouse between several computer base units. Devices that perform this function are useful for conveniently accessing a group computers without the need to

have a keyboard, monitor and mouse connected to each computer base unit. Such devices save on the power, space and equipment needed and are particularly useful for computers such as file servers that only need to be accessed occasionally.

In keyboard, monitor and mouse sharing applications the computer selection is under the control of the user and the switching does not need to occur rapidly. These characteristics enable the current invention to be constructed which can share the keyboard and mouse by switching the associated Universal Serial Bus signals between the host computers using a controllable USB switch. The monitor can be shared straightforwardly by implementing a video switching circuit.

The device can include a switching delay means, in which the switching delay means causes the switching controller to prevent execution of a switching event until an enumeration process between a peripheral and a currently connected one of the plurality of computers has been completed. The switching of USB signals works because USB peripherals are designed to be hot-pluggable and consequently the software within the computers can typically detect the presence of the keyboard and mouse when the USB signals are switched through and configure the computers accordingly. The detection of peripherals is accomplished by an enumeration process that occurs when the USB connection is made. This enumeration process typically takes of order one second or so to complete, although the completion time increases with the number of USB peripherals that are attached. Switching of USB signals during the enumeration process is undesirable as it can lead to erroneous messages being generated by the computer and so is preferably avoided. However, the device

and system can still function to an extent without the enumeration switching delay.

The current invention uses a switching controller circuit and switching delay to ensure that switching of the USB signals does not occur during the enumeration process. The control circuit logs switching requests but only activates the control signal to switch the USB signals when it determines that it is safe to do so. Determination can be based on a simple time delay. Determination can be based on more sophisticated techniques in which the content of data passing between the USB peripherals and USB computers is monitored to determine when the enumeration process has been completed. Only when the enumeration process is complete can the switching event be executed under control of the switching controller.

The switching event request input device can include a manually operable control switch. The device can include a control panel. The device can include a display panel having a visual indicator which indicates which of the plurality of computers is currently connected to the peripheral by the device. The current invention enables the desired computer to be selected by pressing control panel key switches that communicate the switching event request signal to the switching controller circuit. The controller circuit in turn provides a signal to provide a visual indication of the selected computer unit on a display panel. This allows easy and straightforward computer selection when the user is located close to the device.

The switching event request input device can be a keyboard or a mouse. Requesting a switching event by operating a control switch on the device is not convenient for applications where the device is located at some distance from the user's

keyboard, monitor and mouse. In the latter situations it is preferable to be able to select the controlled computer using a keyboard and in particular a keyboard hotkey combination. The implementation of keyboard control is not straightforward because in order to achieve such control the data flowing from the keyboard needs to be analysed and ideally the data corresponding to the hotkey combination needs to be removed from the data stream so that it does not cause unwanted effects on the currently selected computer. Due to the complexity of the USB protocol such data analysis is costly to achieve by monitoring the USB signals.

Preferably the peripheral interface includes an emulator which signals to a peripheral connected to the peripheral interface using a peripheral protocol. The current invention overcomes the difficulty of monitoring all USB signals and allows the keyboard data to be monitored and analysed by implementing a peripheral interface circuit. The peripheral interface circuit emulates the presence of a USB peripheral, and in particular a keyboard, on the Universal Serial Bus.

The emulator can include a PS/2 emulator means which transmits PS/2 protocol signals to PS/2 peripherals connected to the peripheral interface. In this way PS/2 peripherals can be connected to the device while still utilising a USB based switching system to route USB data between the peripherals and computers connected to the device.

The emulator can include USB emulator means which transmits USB protocol signals to USB peripherals connected to the peripheral interface. In this way USB peripherals will behave as though connected directly to a USB host as the USB protocol signals emulate the presence of a USB host to which the USB peripherals have been connected.

The device can include a data extraction means which extracts data in a USB independent format from peripheral data transmitted between the peripheral and the device.

Preferably, the peripheral interface includes a data converter which converts data flowing within the peripheral interface circuit between a USB dependent format and a USB independent format. The data flowing to and from the keyboard is converted between USB signals and USB protocol independent data by a data converting means provided in the peripheral interface circuit. USB protocol independent data can be taken as data that is transferred between two locations or otherwise processed without using the USB protocol.

A switching event request signal can be communicated to the switching controller in response to the extracted USB independent data. The USB protocol independent data can be analysed and manipulated as required by a microprocessor function within the peripheral interface circuit to provide a switching event request signal to the switching controller circuit. The USB independent data which originates a switching event request can correspond to a keyboard hot key sequence. The microprocessor function monitors the data flowing through the peripheral interface circuit looking for data sequences corresponding to the keyboard hotkey codes. When these sequences are found the microprocessor function removes the data so that the hotkey codes are not sent to the computer and then signals the corresponding switching event request to the switching controller circuit.

The device can support USB peripherals and/or PS/2 peripherals. If a PS/2 keyboard is connected to the peripheral interface using a PS/2 connection then the signals transmitted between the keyboard and peripheral interface

include clock and data signals. The data flowing to and from this keyboard is in a USB protocol independent format and can therefore be analysed by the microprocessor function within the peripheral interface circuit.

The peripheral interface can include a peripheral USB data converter which converts peripheral data between the USB independent format and the USB format. Circuitry in the peripheral interface is provided which performs a data conversion from the USB independent format used by PS/2 keyboards to the USB code format used by USB keyboards.

In the case of a USB keyboard connected via a USB connection, the peripheral interface circuit contains the USB emulator that emulates the presence of a USB host computer. This USB host emulator also includes a USB data converter means which converts the data flowing to and from the keyboard between the USB protocol independent data within the peripheral interface circuit and the USB signals used for communication between the host emulator function and the USB keyboard. The overall effect of this type of peripheral interface circuit is therefore to convert the keyboard USB signals into a form that can be analysed by the microprocessor function and then convert these USB protocol independent signals back into USB signals for communication with the currently selected host computer.

The peripheral interface can include a USB hub means in communication with the peripheral data converter and in communication with the USB data transmission means. The peripheral interface circuit preferably contains a USB hub function. This enables a group of USB peripherals such as mice, speakers, joysticks, printers, modems and cameras to be shared together with the keyboard. The structure of this arrangement is very advantageous because a flexible group of

other USB devices are automatically connected to the currently selected computer without the need for additional advanced circuitry. Because the USB signals between the host and these peripherals are not disrupted once a connection has been made, any USB peripheral device can be connected. This enables the user to share a much more flexible group of peripherals than would typically be practical using a non-USB sharing device.

The device can include a plurality of peripheral interfaces in communication with the USB data transmission means and each peripheral interface connectable to a one of the plurality of USB computer interfaces by the switching means. Several USB keyboards and mice can be connected to the same computer base unit and used simultaneously. An embodiment of the current invention makes use of this characteristic in order to implement a keyboard, video and mouse switching device that supports two simultaneous users. The same principle can be used to support more than two users and so systems supporting larger numbers of users are considered to fall within the ambit of the invention. The device can include a second switching means that operates under control of the switching controller in a similar way to the first controllable switching means.

Each USB computer interface can include a USB hub means. In order to enable the switching means to connect a peripheral interface to any of the computers, the device uses a group of computer interface circuits. Each computer is connected to a computer interface circuit which implements a USB hub function. This USB hub function creates a plurality of USB downstream connections that provide the ability to connect the USB switching means to the same computer. The peripheral interface can be connectable by the switching means to an input of each of the USB hub devices. A plurality of

peripheral interfaces can be provided. In this way an any-to-any matrix switching structure can be created allowing any of the connected user peripherals to control any of the connected computers.

The robustness of operation of the device in practical applications is seen as an important characteristic that affects the desirability and value of the device and system to the users. The error free operation of the computer software during and after switch over of the USB switching means is of particular importance. The device can include a switching delay means that increases the reliability of operation in a number of practical applications. However, even with the switching delay means some anomalies are still observed on some computer systems. A typical anomaly of this type is failure of the computer software to detect one or more of the USB peripherals that are attached to the USB hub means after switch over of the USB switching means.

The device can include a peripheral connector device in communication with the USB hub means and to which peripherals can be attached, the connector device being in communication with the switching controller and operable under a control signal to connect or disconnect the USB hub and a peripheral attached to the connector device. The connector device allows peripherals to be selectively connected to and disconnected from the USB hub at certain times during a switching procedure thereby improving the robustness of operation of the device. A separate connector device can be provided for each port of the USB hub. The connector device can connect or disconnect peripherals by controlling power signals or data signals.

The USB peripheral connector device is used in conjunction with the USB switching means to increase the robustness of

operation of the invention and consequently reduce the number of anomalies seen in some practical applications. The peripheral connector device can be inserted into the links between the USB hubs means and the USB peripherals. The peripheral connector device can be in communication with the switching controller and the switching controller can be in communication with the USB hub. The USB hub means is intelligent and can detect the attachment or detachment of the USB peripherals to the USB hub by its downstream ports. By using the connector device together with the USB switching means the switching controller operate the switching means and connect and disconnect peripherals attached to the USB hub to effect a more reliable switching strategy.

A number of USB keyboards are fitted with a power on/off key. This power key enables the user to power on and power off the computer from the keyboard. Power on may be effected from a low-power suspended state that the computer goes into if it is switched off but still connected to the mains power. In one particular model of computer, the power off signalling is achieved by transmitting a key press signal from the keyboard to the computer via the USB. The power on signalling is more complicated because the computer is not fully powered and the USB is therefore not fully active. The power on signalling is therefore achieved by the keyboard connecting the USB data minus signal (D-) to ground using a small resistor. This change is detected by the computer and causes the computer to power up.

However, this type of power on signalling is not transmitted through a USB hub and so the power on function of the power key is lost if the keyboard is connected to the computer via a standard USB hub.

The device can include a USB hub bypass which includes switching means to selectively connect a peripheral device connectable to the USB hub directly to a computer side of the USB hub, thereby bypassing the USB hub.

The hub bypass acts to bypass the hub under certain conditions and connect a single preferred USB downstream connection of the hub directly to the computer side, USB upstream connection of the hub whilst simultaneously isolating the hub means. The requirement to bypass the hub can be detected by monitoring the power (Vbus) signal on the USB upstream connection. This power signal is not active on the USB connection from some computers whilst the computer is powered down so this signal can be used to detect when to bypass the hub. The power signal can be used directly to control the bypass means. Preferably the power signal is fed into a signal conditioning circuit to create a hub bypass control signal. The signal conditioning circuit can also take in information from other sources so that the hub bypass action can be prevented by the system.

The application of a hub bypass means is currently most relevant to Apple Macintosh computers and keyboards. The same solution is applicable to any other computer keyboards that implement similar power functions.

Each USB computer interface can include a USB data converter and the device can include a bi-directional data transfer means in communication with each USB computer interface and providing bi-directional data transfer between computers connected to the device via respective USB computer interfaces. The use of computer interface circuits has an associated advantage because the particular circuitry used to implement them can also enable an additional inter-computer file transfer facility to be supported. This is achieved by

providing a USB data converter that implements a bi-directional communications function within each computer interface circuit that can convert USB signals into two-way data that can be transferred between the various computer interface circuits. This data transfer is achieved over a bi-directional data transfer means using an I^2C (Inter-IC Communication) bus that is connected to each computer interface and enables any computer interface to send and receive data from all other computer interfaces. When coupled with file transfer software running on each of the connected computers, this system enables files to be transferred between computers whilst simultaneously allowing peripherals to be shared. This features makes the invention particularly useful for applications where a single keyboard monitor and mouse is to be used to control a desktop PC and a laptop that are not otherwise networked together.

The device can include a computer video signal interface for receiving a computer video signal from each of the plurality of computers, a video signal output and a video signal switching means controlled by the switching controller and operable by the switching controller in response to a switching event request signal to connect a computer video signal from a one of the plurality of computers to the video signal output for display on a video display device connected to the video signal output. Preferably, the device includes a plurality of video signal outputs and the computer video signal interface including a computer video signal splitting means which splits each computer video signal into a number of signals corresponding to the number of video signal outputs, in which the video signal switching means provides a connectable path for a computer video signal from each of the plurality of computers to each video signal output. A matrix video switching circuit can be coupled to this USB switching

system so as to allow a video picture from a controlled computer to be switched together with the USB signals.

The device can enable three computers to be accessed from two user stations that each support a keyboard, monitor and mouse and a group of other USB peripherals. It will be appreciated that the invention is not limited to only three computers and two user stations. The device can be used to control more or less computers and may also have more or less user stations that may have a mixture of characteristics such as the number of USB downstream ports and the connectivity provided for the controlling keyboard. Also, devices that have USB switching facilities only and no video switching circuitry have a number of uses. Consequently a wide variety of USB switching systems are considered to fall within the ambit of the current invention.

According to an aspect of the invention there is provided, a Universal Serial Bus data transfer device for connecting a peripheral to a one of a plurality of computers connected to the device and transferring data between the plurality of computers, comprising: a respective USB data converter for each computer connected to the device and which converts USB computer data communicated between the computer connected to the USB data converter and the USB data converter between USB computer data and a USB independent format data; a bi-directional data transfer means in communication with each USB data converter and providing bi-directional transfer of USB independent format data; a peripheral interface to which the peripheral is connected; and a USB data transmission means in communication between the peripheral interface and a one of the plurality of USB data converters, in which a peripheral device connected to the peripheral interface can be used to effect data transfer between any of the plurality of computers connected to the device.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a functional block diagram of a device and system according to aspects of the invention;
Figure 2 shows a functional block diagram of a video signal switching part of the device; and
Figure 3 shows a schematic circuit diagram illustrating a hub bypass part of the device.

The same items in different Figures share common reference numerals. The Figures show functional block diagrams only and the location of the functional blocks is not intended to specify a particular configuration of separate devices. The block diagram merely indicates the functions performed and the functional relationships of the functions. A particular function may be distributed amongst various real world components and equivalently a number of functions, or parts of different functions, may be realised by a single real world component, e.g. a microprocessor and associated memory.

Figure 1 show a block diagram of a USB switching device, designated generally by reference numeral 100, according to the invention and a USB switching system, designated generally by reference numeral 110, including a plurality of computers 112 and peripherals 118 connected to the device 100. The example shown in Figures 1 and 2 is a device and system that enables two users to control three computer base units. Each user is able to connect a mouse 116 and other USB peripherals 118 in addition to a keyboard 120 and monitor 122. According to the system, these peripherals are then connected via the device 100 to a one of the computer base units 112 that is currently being controlled by the user's keyboard and whose video is currently being displayed on the

user's monitor. For clarity, the elements of the invention that are mainly concerned with controlling the switching process and switching the USB signals are shown in Figure 1 and the elements that are mainly concerned with switching the video signals are shown in Figure 2.

With reference to Figure 1, the USB switching device 100 includes a plurality of USB computer interfaces 122. A one of the plurality of computers 112 is connected to a respective computer interface. Each computer is connected to the device via a Universal Serial Bus connection 124 that may include a USB hub 126. Each computer interface circuit 122 includes a USB hub function 128 and a USB computer data converter and communications device 130. The USB hub 128 links to the computer 112 via an upstream connection 132 and provides two downstream connections 134,136. A bi-directional data transfer means 138 is provided in communication with the computer USB data converter and communications device 130 of each of the computer interfaces. Each computer interface circuit 122 can be implemented by a Cypress CY7C66113 microcontroller and associated components (not shown). The Cypress CY7C66113 is an 8-bit microcontroller that contains integrated USB hub support and can be used as a USB peripheral controller. The version used to implement the preferred embodiment of the invention is a one-time-programmable (OTP) part with internal RAM and program memory.

The device includes a first and a second USB switching means 140,142. The device includes a first and a second peripheral interface 160,162. Each controllable USB switch 140,142 has three upward connections 144 that are linked to the computer interface circuits 122 and a downward connection 146 that is linked to one of the peripheral interface circuits 160,162. A USB data transmission means 148 is provided between each

peripheral interface 160,162 and any one of the computer interfaces which is connectable by the USB switches 140,142. The controllable USB switch 140,142 connects the USB data signals (data + and data -) from the downward connection 146 to one of the upward connections 144 according to a control signal 150,152 communicated to the switch by a switching controller 154. The switching controller is in communication with a switching delay means 156 which can delay a switching event of the USB switches until an enumeration process has been completed. The controllable USB switch 140,142 is also able to disconnect the downward connection 146 from all upward connections 144. Each controllable USB switch 140,142 can be implemented using a Pericom PI5C3253 dual 4 to 1 multiplexer.

The peripheral interface circuit 160 contains a Cypress CY7C66113 microcontroller which is identical to the component as used to implement the computer interface circuits 122. Again this peripheral interface contains a USB hub 164 that links to the downward connection 146 and provides four downstream USB connections 166 which can be connected to USB peripherals 114 either directly via a USB link 170 or indirectly via USB hub 167. Typical USB peripherals that would be used with the device are mice 116, speakers 169 and microphones 168 although the device is not limited to supporting just these types of devices. The peripheral interface circuit 160 contains a USB keyboard emulator 172 that is mainly implemented by the peripheral controller function of the Cypress CY7C66113 microcontroller. This keyboard emulator function 172 performs a conversion between USB signals and USB protocol independent keyboard data that can be analysed and processed by the peripheral interface's microprocessor 174 without continuously monitoring the changing states of the USB signals. USB protocol independent data can be taken as data that is transferred between two

locations or otherwise processed without using the USB protocol. A USB host emulator 176 within the peripheral interface circuit 160 performs the reverse task of the keyboard emulator circuit 172 and converts USB protocol independent keyboard data into USB signals that flow over a Universal Serial Bus link 178 to and from the controlling keyboard 120. The host emulator function is mostly implemented using a Cypress CY7C67113 USB mini-host microcontroller. Like the CY7C66113, this part is an 8-bit OTP microcontroller that is specifically designed for USB applications. It has internal RAM and program memory and supports a single USB peripheral, which in this case is the controlling keyboard 120.

Although a separate microcontroller could have been used to implement the microprocessor function 174 there are sufficient microprocessing resources within the CY7C66113 and CY7C67113 to implement the required functions. Consequently the microprocessor function is implemented by both devices working in combination. The microprocessors monitor the flow of keyboard data to look for data corresponding to the keyboard hotkey combination being presses and released within a defined short time period. Once this event has been detected the microprocessors prevent all key press information being sent to the currently selected computer and starts waiting for the keyboard keys 1,2 or 3 to be pressed by the user.

When the user depresses key 1, 2 or 3 this is detected by the microprocessor function 174 and a control signal 180 is communicated to the switching control circuit 154 as a switching event request signal to request the corresponding computer to be connected by the controllable USB switch 140 that is connected to the peripheral interface circuit 160. The switching event is not executed until the switching delay

circuit 156 has determined that an enumeration process between the peripherals 118 and the computer currently connected by the switch 140 has been completed. This provides a USB data transmission means between the computer and peripheral interfaces. The microprocessor function 174 then sends all further keyboard information to the currently selected computer. In this way a hotkey combination typed on the controlling keyboard 120 can be used to generate the switching event request signal to select the computer that all the 'User A' peripheral devices 114 are connected to. The keyboard provides a switching event request input device. In addition to selecting channels 1,2 and 3 by depressing keys 1,2 or 3, the user can disable a video signal and/or disconnect the USB peripherals by depressing key 0 or select an auto-scan mode under control of microprocessor 174 by pressing key 9. In auto-scan mode the video picture from each computer is displayed for a defined period of time so that the user can continuously monitor the state of the connected computers.

The device includes a control panel circuit 182 including a control panel 183 having visual indicators 184 and manually operable control switches 186 in communication with the switching controller 154. The currently selected computer for a user of the left hand set of peripheral devices (User A) is visually indicated on the control panel 183. An indicator light 184 is provided for each computer which is illuminated when the corresponding computer is currently selected. Means are provided to cause the light to flash during the period immediately after a new computer has been selected when no further channel changes are allowed so as to allow the enumeration process to be completed. The control panel circuit 182 also includes three key switches 186 that enable user A to select the required computer without using the keyboard hotkey combination. The manually operable

switches 186 provide a further switching event request input device which can generate a switching event request signal 188 that is communicated to the switching controller 154.

The device includes a second peripheral interface 162 to which the right hand set of peripherals 115 shown in Figure 1 of a user (User B). The peripheral interface circuit 162 is similar to the first peripheral interface circuit 160 with the difference that the controlling keyboard 190 is connected via a PS/2 link 192 rather than a USB link. Consequently peripheral interface circuit 162 does not contain a USB host emulator function 176 and instead contains a PS/2 interface and emulator 194 that emulates connection of the PS/2 peripherals to a PS/2 system. The PS/2 interface function 194 communicates with the controlling keyboard 190 and a PS/2 mouse 191 via bi-directional PS/2 links 192,193 that contain clock and data signals that operate in a PS/2 compatible manner.

Like peripheral interface circuit 160, circuit 162 can be realised using a Cypress CY7C66113 which implements a USB hub function 200 that links to the downward connection 146 of the USB switch and produces four downstream USB connections 202 which can be connected to USB peripherals 118 either directly via a USB link 204 or indirectly via a USB hub 206. Figure 1 shows these downstream connections linked to a set of speakers 207, a microphone 208 and a printer 209 although other USB peripherals could also be connected. Downstream connection can be left unconnected if they are not required for the application.

A keyboard and mouse USB emulator 198 is mostly implemented using the Cypress CY7C66113 contained within the peripheral interface circuit 160. It operates in a similar way to the keyboard USB emulator 172 contained within peripheral

interface circuit 160. This keyboard and mouse USB emulator function 198 performs a conversion between USB signals 201 and USB protocol independent keyboard and mouse data 199 that can be analysed and processed by the peripheral interface's microprocessor function 196 without continuously monitoring the changing states of the USB signals. The microprocessing function 196 and the PS/2 interfacing 194 and data converter are together implemented by an Arizona Microchip PIC16C67 OTP microcontroller. This converts the PS/2 keyboard and mouse data from the formats used by PS/2 keyboards and mice into the formats used by USB keyboards and mice. The microprocessing function 196 also monitors the keyboard data for keyboard hotkeys in a similar way to microprocessor 174 described earlier and, where required, disables the flow of keystroke information to a connected computer 112. When a hotkey sequence is detected the peripheral interface circuit 162 generates a switching event request signal 210 which is communicated to the switch controller circuit 154 which, dependent on an enumeration process being complete, controls the state of the controllable USB switch 142 that is attached to peripheral interface circuit 162 to connect the peripheral interface to a selected USB computer interface by a USB data transmission path. In this way a hotkey combination typed on the controlling PS/2 keyboard 190 can be used to select the computer that all the 'User B' peripheral devices are connected to. The keyboard 190 provides a switching event request input device.

PS/2 connections are relatively cheap and simple to implement and so the PS/2 interface 194 can also implement a PS/2 mouse connection 193 in addition to the PS/2 keyboard connection 192. This means that the microprocessor function 196 is able to process and analyse the mouse data in addition to the keyboard data. This information is processed in a way that enables the user to cycle between the selected channels using

a 3 button mouse. The processing function 196 analyses the mouse data for all mouse reports that indicate that the central mouse button is held down which are removed from the data stream that flows to the computer. If the left hand mouse button is pressed whilst the central button is held down a request to change to the next channel (in sequence 1,2,3,1,2 etc.) will be sent to the switch controller circuit 154. If the right hand mouse button is pressed whilst the central button is held down a request to change to the previous channel (in sequence 3,2,1,3,2 etc.) will be sent to the controller 154. In this way the PS/2 mouse 191 can be used as a switching event request input device to select the computer that all the 'User B' peripheral devices are connected to.

The device includes a second control circuit 212 in communication with the switch controller 154 including a control panel 214 bearing three visual display means 216 and three manually operable switches 218. The currently selected computer for 'User B' is indicated on the control panel 214 by an indicator light provided for each computer which is illuminated when the corresponding computer is currently connected. This light flashes during the enumeration process period immediately after a new channel has been selected when no further channel changes are allowed. The control panel circuit 212 also includes three key switches 218 that enable user B to select the required computer without using the keyboard hotkey combination or the mouse.

The switching controller circuit 154 is mainly concerned with controlling the two USB switches 140,142 and two video switches 250,260. It achieves this by generating a number of control signals 150,152,252,262 which are linked to the respective switches. A number of user operable option switches 220 are included in the device and are connected to

the switch controller. The switch controller circuit 154 reads the states of the bank of option switches 220 which the user can set to select various operating parameters such as the channel change dwell time (minimum channel time that a computer is selected) and the auto-scan cycle time (the amount of time that the video from each computer is displayed during the auto-scan process).

The switch controller circuit of the preferred embodiment of the invention is implemented using an Arizona MicroChip PIC 16F877 microprocessor with some associated components and interfacing circuitry. This microprocessor is clocked by means of a timing circuit that contains a timing crystal and consequently has access to timing information. For other more simple embodiments of the invention, such as a device designed for a single user, this controller circuit could more efficiently be implemented using spare facilities and input/output connections available on the microprocessors contained within the peripheral interface circuit.

The controller circuit interprets the signals 180,188 from the peripheral interface circuit 160 and the control panel circuit 182 and processes these, taking account of timing information and the options selected by the user, to create the control signals 150 and 252. It also controls the state of the indicator lights 184 on the control panel circuit that indicate the computer that user A is currently connected to. Signals 150 and 252 usually operate together so that user A's video signals and USB signals are connected to the same computer 112. However the video switching can be operated independently from the USB switching. This is useful in an auto-scan mode when the video picture only is switched. Each switching request from circuit 160 or 182 may be delayed to ensure that switch over of USB signals does not occur during the enumeration process associated with a previous switching

event. The video signals can be switched without restriction and so video switching occurs immediately upon request.

Similarly the controller circuit interprets the signals 210,219 from the peripheral interface 162 and the control panel circuit 212 and processes these taking account of timing information and the options selected by the user, to create the control signals 152 and 262. It also controls the state of the indicator lights 216 on the control panel 214 that indicate the computer that user B is currently connected to. Again, signals 152 and 262 usually operate together so that user B's video signals and USB signals are connected to the same computer but can also be operated independently. As with the control signals from the user A circuitry, the control signals from the user B circuitry can be acted on immediately or delayed as required.

The communications functions 130 of the computer interface circuits are connected together using an I^2C (Inter-IC Communications Bus) 138 that allows data to be transferred from any computer interface circuit 122 to any other computer interface circuit 122. The data transfer is implemented in such a way that the source of the data is identified so that the computer interface circuit that is receiving the data can identify which computer 112 the data has come from. The peripheral controller function of the Cypress CY7C66113s contained within the computer interface circuits 122 is used to implement the communications function. Conveniently the CY7C66113 has an integrated I^2C controller aiding implementation.

The peripheral controller 130 is used to implement an inter computer data transfer function that can be visualised as two bi-directional RS232 ports that, when coupled with software 113 running on the computer 112, enable the computer to

independently communicate with a modem or other computer attached to each of the RS232 ports. This visualisation helps to explain the functionality of the communications devices 130 of the computer interfaces of the device. Data received from the other computers via the computer interface circuits 122 and the I^2C bus 138 is split into two logical data streams by the communications function 130. Each of these data streams is equivalent to the data being received at one of the RS232 ports of the visualised system. The destination of any file transfer data sent from the computer is attached to the data by the software running on a computer in such a way that each communications function 130 is able to split the data into two logical data streams, each one destined for one of the other computers. Each of these data streams is equivalent to the data being transmitted from one of the RS232 ports of the visualised system. It can therefore be seen that data can be freely transferred from any of the three computers to any other of the three computers by using a combination of computer software running on each computer, a USB link to each computer 124 and a group of computer interface circuits 122 connected to each computer via the USB link and connected to each other via an I^2C bus 138.

The device also includes a peripheral connector device 300 connected to the downstream outlets 166 of the USB hub means 164. Although the peripheral connector device is shown in Figure 1 as external to the device, this is only for the sake of clarity and in reality the peripheral connector device will be provided as an integral part of the device. A number of peripheral devices are attached to the connector device. The device includes switching means operable to connect or disconnect individual peripheral devices to the USB hub 164. The connector device is in communication 302 with the switching controller and receives control signals therefrom

sufficient to selectively connect or disconnect the individual peripheral devices to the USB hub.

The peripheral connector device, which is also a disconnector device, can be effected by a Texas Instruments TPS2044 power distribution switch and some associated logic circuitry. This component is a quad power switch that would provide four switching means thereby providing four peripheral connector devices to enable four peripherals to be connected/disconnected by switching off power signals. A peripheral connector device could also be provided by a Pericom PI5C3253 dual 4 to 1 multiplexer configured to disconnect the USB data signals.

The peripheral connector device is in communication with the switching controller. Control signals are provided between the switching controller 154 and the peripheral connector device to connect and disconnect peripherals physically attached to the USB hub. The USB hub means 164 is an intelligent device and detects the physical attachment or detachment of the USB peripherals at its downstream ports 166. By using the peripheral connector together with the USB switching means the switching controller may effect a more reliable switching strategy.

This switching strategy may be understood by considering the sequence of switching events during a switchover cycle. Firstly the switching controller signals to the peripheral connector 300 to disconnect the USB peripherals from the USB hub means by operating the switching means in the connector (event A). The USB hub means detects these disconnection events and communicates this information back to the currently selected computer. The switching controller then waits for a short time period to allow the computer's software to register the changes and stabilise (time delay

AB) before signalling to the USB switching means to switch to the next computer (event B). The next computer will then detect the attachment of the USB hub means and configure itself accordingly. The switching controller then waits for a short time period to allow the computer's software to register the changes and stabilise (time delay BC) before signalling to the USB peripheral connector device 300 to connect the USB peripherals (event C) by operating the switching means in the connector device. The computer will then detect the connection of these peripherals and configure itself accordingly.

It is believed that the increase in robustness is achieved because the USB peripherals are connected and disconnected in two stages rather than all at once and that the software in the computers is more able to cope with the two separate and distinguishable events.

A USB data cable carries four signals which may be identified as ground (Gnd), power (Vbus), data plus (D+) and data minus (D-). A connector device may be implemented by switching off the power or by disconnecting the USB data signals or by a combination of the two. In practice it is easier to switch off the power and so this method is preferred for cost reasons.

Referring now to Figure 2, each computer 112 is connected to the device 100 via a video cable 240 that carries red, green and blue video colour signals and horizontal and vertical picture synchronisation signals. The device includes a computer video signal interface 242, a computer video signal outputs 244 and video signal switches 250,260. Each of the video signal cables is connected to a video fan-out circuit 246,248,249 that terminates the video cable and fans out the video signals to each of the two video switches 250,260. The

fan out circuits provide video signal splitting means. The major components within these fan-out circuits are termination resistors.

The video switches 250 and 260 connect the output video signals 264,266 to one of the input video signals 268,269,270 depending on the state of the control signals 252,262. The output video signals 264,266 can also be disconnected from any of the input video signals to disable the video pictures on the monitors 122. The video switches 250,260 switch the red, green and blue colour signals and the horizontal and vertical synchronisation signals together so that the video picture from the chosen source computer can be displayed on the respective monitor. Each video switch is implemented mainly using two Pericom PI5V330 quad 2-to-1 switches to switch the red, green and blue video colour signals and a 74LS153 dual 4-to-1 multiplexer to switch the horizontal and vertical synchronisation signals.

The red, green and blue signals within the video output signals 264,266 are buffered by buffer circuits 272, 274 to produce video signals that are suitable for transmission across video cables 276,278 to respective video monitors 280,282. Each of these buffer circuits contains a Maxim MAX499 plus some associated components. The horizontal and vertical synchronisation signals do not need to be buffered further as the output signals from the video switch circuits are suitable for direct connection to the video cables 276,278. Monitor 280 is associated with the first set (User A) of peripherals and generally shows the video that is being produced by the computer that the user A peripherals are currently connected to. Similarly, monitor 282 is associated with the second set (User B) of peripherals and generally shows the video that is being produced by the computer that the User B peripherals are currently connected to.

The overall effect of the complete device is to enable a system to be provided that allows multiple users (in this case two) to simultaneously access multiple computers (in this case three) using a keyboard, monitor, mouse and a group of USB peripherals whilst simultaneously supporting file transfer facilities between the computers.

With reference to Figure 3 a hub bypass part of the device is shown, designated generally by reference numeral 350, to enable a peripheral device to be selectively connected directly to a computer under certain circumstances. The bypass includes a first switching device 352 operable to switch a keyboard connected to input 354 between an input 356 of USB hub 358 and a second switching device 360. The second switching device is provided on a computer side of the USB hub, between the output of the USB hub 364 and the USB switching device 140. A connection 362 between the switching devices 352, 360 bypasses the hub 358. The second switch is operable to connect either the bypass connection 362 or the output line 364 of the hub to the computer side line 148 connected to the switching device 140. A control circuit 364 provides control signals to operate the switches 352,360. The control circuit monitors the Vbus signal on line 366 and can monitor signals 369 from the rest of the device provided on line 368 to allow the bypass function to be disabled.

The bypass 350 bypasses the USB data minus signal (D-) and preferably bypasses the USB data plus signal (D+) as well. The bypass may be implemented by a Pericom PI5C3257 quad 2 to 1 bus switch and the control circuit 364 may be implemented by logic or microprocessor circuitry.

In operation, the USB bypass 350 allows connection of the upstream line 148 and the preferred downstream connection 356 directly. The bypass operates in such a way that it connects

the USB upstream connection 148 to the USB downstream connection 354 either via the USB hub 358 (switches in position A) or via the bypass link 362 (switches in position B) according to the control signal 370 that is supplied from the control circuit to the switches 352,260.

The control circuit monitors the Vbus signal 366 associated with the USB upstream connection 148 in order to create the control signal 370. When Vbus is low, i.e. computer off and therefore USB off, the switches are operated to bypass the hub by connecting the keyboard directly to the computer. Therefore, when the power on key is actuated on the keyboard the D- and/or D+ USB data signals are transmitted directly to the computer enabling it to power on. The switches 360, 352 are then operated into the A position so that further signals are directed through the USB hub. The signal conditioning circuit may also take account of other information signals 368 so that the bypass function may be disabled.

A similar USB hub bypass device can be required to bypass the USB hub 128 when provided in the computer interface 122. Adaptation of the bypass device shown in Figure 3 to provide this facility is considered to be within the knowledge of a man of ordinary skill in the relevant art.

CLAIMS:

1. A Universal Serial Bus switching device for connecting a peripheral to a one of a plurality of computers comprising:

a peripheral interface;

a plurality of USB computer interfaces;

a switching means;

a USB data transmission means connectable between the peripheral interface and a one of the plurality of USB computer interfaces by the switching means;

a switching controller in communication with the switching means to control a switching event which connects the peripheral interface to a one of the plurality of USB computer interfaces; and

a switching event request input device which when operated causes a switching event request signal to be communicated to the switching controller, causing the peripheral to be connected in communication with a one of the plurality of computers.

2. A device as claimed in claim 1, and including a switching delay means, in which the switching delay means causes the switching controller to prevent execution of a switching event until an enumeration process between a peripheral and a currently connected one of the plurality of computers has been completed.

3. A device as claimed in claim 1, in which the switching event request input device includes a manually operable control switch.

4. A device as claimed in claim 1, in which the switching event request input device is a keyboard.

5. A device as claimed in claim 1, in which the switching event request input device is a mouse.

6. A device as claimed in claim 1, in which the peripheral interface includes an emulator which signals to a peripheral connected to the peripheral interface using a peripheral protocol.

7. A device as claimed in claim 6, in which the emulator is a PS/2 emulator and the peripheral protocol is the PS/2 protocol.

8. A device as claimed in claim 6, in which the emulator is a USB emulator and the peripheral protocol is the USB protocol.

9. A device as claimed in claim 1, in which the peripheral interface includes a data extraction means which extracts data in a USB independent format from peripheral data transmitted between the peripheral and the device.

10. A device as claimed in claim 9, in which a switching event request signal can be communicated to the switching controller in response to the converted USB independent format peripheral data.

11. A device as claimed in claim 9 or claim 10, in which the peripheral interface includes a peripheral data converter which converts peripheral data between the USB independent format and the USB format.

12. A device as claimed in claim 1, in which the peripheral interface includes a USB hub means in communication with the USB data transmission means.

13. A device as claimed in claim 1, and including a plurality of peripheral interfaces in communication with the USB data transmission means and each peripheral interface connectable to a one of the plurality of USB computer interfaces by the switching means.

14. A device as claimed in claim 13, in which the switching event request input device can initiate independent switching events for the peripheral interfaces.

15. A device as claimed in claim 13, in which each USB computer interface includes a USB hub means.

16. A device as claimed in claim 15, in which each peripheral interface is connectable by the switching means to a port of each of the USB hub means.

17. A device as claimed in claim 15, in which each USB computer interface includes a USB data converter and the device includes a bi-directional data transfer means in communication with each USB computer interface and providing bi-directional data transfer between computers connected to the device via respective USB computer interfaces.

18. A device a claimed in claim 1, and including a computer video signal interface for receiving a computer video signal from each of the plurality of computers, a video signal output and a video signal switching means controlled by the switching controller and operable by the switching controller in response to a switching event request signal to connect a computer video signal from a one of the plurality of computers to the video signal output for display on a video display device connected to the video signal output.

19. A device as claimed in claim 18, and including a plurality of video signal outputs and the computer video signal interface including a computer video signal splitting means which splits each computer video signal into a number of signals corresponding to the number of video signal outputs, in which the video signal switching means provides a connectable path for a computer video signal from each of the plurality of computers to each video signal output.

20. A device as claimed in claim 12, and including a peripheral connector device in communication with the USB hub means and to which a peripheral can be attached, the connector device being in communication with the switching controller and operable under a control signal to connect or disconnect the USB hub and the peripheral attached to the connector device.

21. A device as claimed in claim 12, and including a USB hub bypass, the bypass including switching means to selectively connect a peripheral device connectable to the USB hub directly to a computer side of the USB hub, thereby bypassing the USB hub.

22. A system including a device as claimed in any preceding claim and including a plurality of computers connected by USB connectors to respective USB computer interfaces of the device and a peripheral connected to the peripheral interface of the device.

23. A Universal Serial Bus data transfer device for connecting a peripheral to a one of a plurality of computers connected to the device and transferring data between the plurality of computers, comprising:

a respective USB data converter for each computer connected to the device and which converts USB computer data

communicated between the computer connected to the USB data converter and the USB data converter between USB computer data and a USB independent format data;

a bi-directional data transfer means in communication with each USB data converter and providing bi-directional transfer of USB independent format data;

a peripheral interface to which the peripheral is connected; and

a USB data transmission means in communication between the peripheral interface and a one of the plurality of USB data converters, in which a peripheral device connected to the peripheral interface can be used to effect data transfer between any of the plurality of computers connected to the device.

24. A device as claimed in claim 23, in which the peripheral device is a keyboard.

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Claims searched: 1

Examiner: Leslie Middleton
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Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): G4A (AFGDC, AFGT)

Int Cl (Ed.7): G06F 13/12, 13/38, 13/40

Other: ONLINE: EPODOC, JAPIO, WPI / EPOQUE

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, E	EP 0982663 A	(Matsushita EIC) See Figure 3,including the selector 6 (page 7, lines 1-8) especially	1 at least
A	JP 10301898 A	(Casio Computer) See abstract	
A	JP 10187303 A	(Hitachi) See abstract	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.